An Overview of 5G network and its Architecture

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Abstract

5G is a network with a quick response system to link everything through the internet for large-scale data sharing. 5G is provided wireless cellular network by providing faster speed, high capacity and low latency. Although 5G service providers are assure integrity, confidentiality and availability of data, still security is an important concern that needs to be addressed. In this paper we have studied how to evaluate 1G network to 5G network and architecture of 5G networks.

Keywords—5G, Cellular network, Wireless Communication, Security, Latency, Architecture

I.   INTRODUCTION

5G is the 5th generation mobile network. 5G denote the next major phase of mobile telecommunication standards of mobile network was deployed in Japan in Tokyo during 1979. This system used analogue signals first generation had poor battery life and voice quality dropped calls or many disadvantages due to technology limitations. In this point we have to discuss the evolution of mobile networks from 1G to 5G.

1G (First Generation)

1G is the first generation of mobile communication technology, created in 1980, it is a cellular wireless telephone system based on analog technology, now an obsolete analog mobile network, in the history of wireless communication, and it took the first chair. 1G is the analog communication technology, and 1G wireless system are designed to transmit voice traffic only and are limited by network capacity. Although coverage was limited and rates low, intercommunication was freed from fixed telephone lines.1G was capable to support up to 2.4kbps.

2G (Second Generation)

2G systems introduced a new digital technology for wireless transmission also known as Global System for Mobile communication (GSM) & Code Division Multiple Access (CDMA) system.2G designed for voice call or improved coverage & capacity. 2G was capable of supporting up to 64kbps data rate which is sufficient for picture, SMS, MMS and email services.

3G (Third Generation)

3G was designed for voice with same data consideration.3G mobile communication started with the introduction of Universal Mobile Terrestrial .3G has the data rate of 384kbps and it support, more data plus video calling for the first time on mobile devices.3G also support internet access through phone and also first mobile broadband 2000kbps in that 2 mbps for stationary and 384 kbps for moving.

4G (Fourth Generation)

4G designed primarily for data. High speed& capacity of data transfer rate is high.IP based protocols are used. Long term evaluation (LTE) wireless technology used in the 4G.4G is used for download high resign video. Mobile broadband 100,000 kbps.

5G (Fifth Generation)

5G is a 5th generation mobile technology.5G has high speed mobile network. 5G wireless technology is meant to deliver higher multi-5G is a network with a quick response system to link everything through the internet for large-scale data sharing. 5G is provided wireless cellular network by providing faster speed, high capacity and low latency. Although 5G service providers are assure integrity, confidentiality and availability of data, still security is an important concern that needs to be addressed. This paper provides a detailed 5Gnetwork Advantage, common threats targeting 5G network along with their mitigation strategies, security services offered by 5G networks and 5G security challenges. This technology used optical fire wire. 5G technology is provide wide area coverage, high throughput at millimeter waves (10 mm to 1 mm) covering a frequency range of 30 GHz to 300 GHz.

Key features of 5G system

Ultra fast mobile internet up to 10Gbps

Low latency in milliseconds (significant for mission critical applications)

Total cost deduction for data

Higher security and reliable network

Uses technologies like small cells, beam forming to improve efficiency

Forward compatibility network offers further enhancements in future

Cloud based infrastructure offers power efficiency, easy maintenance and upgrade of hardware

II.   5G Network Architecture

There are two types of Network Architecture are as below:

1. Core Reference Point Architecture
2. Service Based Architecture

1. Core Reference point architecture

The core network is the core part of the cellular communication system, which is behind the scene from the users' perspective unlike the radio part but is instrumental in providing services to the users. Some of the basic and crucial functions that the core network offers are authentication and authorization and to maintain the location of the users so that services can be delivered to them.
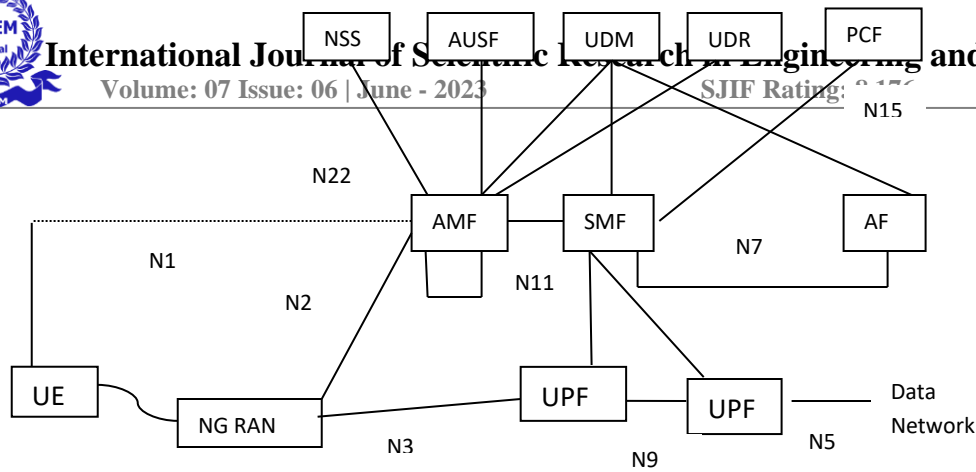
Fig. Core Reference Point Architecture

The above diagram is the reference point representation which shows that how various network functions interact with each other.

1) **Network Repository Function (NRF**) - NRF is used to maintain and collect information. The NRF supports NF service discovery. A component of the 3GPP architecture that provides service discovery between individual network functions.

2) **Policy Control Function(PCF**) - PCF provides a unified policy framework governing network behavior, with tasks such as providing the other CP functions with the policy rules to be enforced.PCT is a front-end interface.NF is access subscription information for policy decisions which stored in the unified data repository UDR.

3) **Session Management Function (SMF)** – SMF is used for handles all of the functionalities related to the management protocol. SMF is also selects and controls the user plane function and handles paging in session management. This architecture fundamental element establishes and manages sessions.

4) **Access and Mobility Management Function(AMF)** – AMF is the termination point of the non-access stratum(NAS) performing functionality function such as registration management, access authentication ,mobility management, connection management, reach ability and user authentication. This function handles session management messages coming from the core network toward the RAN.

5) **Unified Data Management (UDM)** – UDM is manages information related to the UE.UDM tasks are the 3GPP Authentication and Key Agreement credentials, user identification handling, and storing of data related to registration management of NFs.

6) **Network Data Analytics Function (NWDAF) -** It is provides other NFs with analytics information on the network behavior, such as load level information on a slice level**.**

7) Authentication Server Function (**AUSF)** -Implements authentication and security functions. The AUSF stores authentication keys.5g network component is used to facilitate security processes and au authenticates UEs and stores authentication keys.

8) Network Slice Selection Function (NSSF) – It is introduced 5G to determine the set of network slices that a certain UE is allowed to access. This determines the set of candidate AMFs suitable to serve the UE. The AF is stand for application function is interacting with other 5G core network.

9) User Plane Function (UPF) – User plan function is the only node in UP and implements functionalities of packet routing and forwarding. The UPF acts as an anchor point for intra/inter T RAT mobility and an external point of interconnect to a data network for PDU sessions**.** The user plane function includes features to support packet routing and interconnection to other data networks, forwarding, and policy enforcement. Also known as the data plane.

2. Service based architecture

In Service Based Network Architecture diagram all are interface are created like an API. All network function communicated by using restful API.API is an Application program interface. When you want to talk with network function then you used restful API .In this architecture HTTP2 serialization protocol is JSON (Java script object notation) in infrastructure intensively used.5G architecture and LT architecture are similar. Control plane device manage majoring the signaling. In User plan device have only one device their name is UPF (User plane function) it is used for external data network connection this is DN (Data Network).
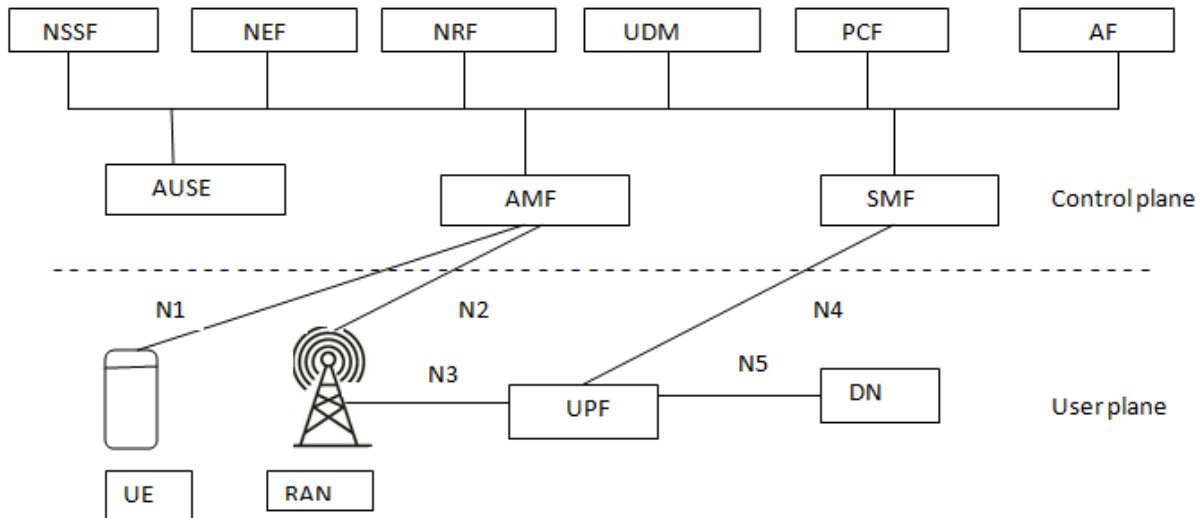

Fig-Service Based Architecture

5G Service Based Network Function

The primary network functions (NF) and their capabilities as defined in the standard today are as follows:

1. **Authentication Server Function (AUSF):**

   It acts as an authentication server. It primarily has EAP authentication server functionality and acts as storage for keys and provides keying content to requesting NFs.

2. **Access and Mobility Management Function (AMF):**

   It includes NAS signaling, NAS ciphering and integrity protection, registration termination management, connection management, mobility management, access authentication and authorization, security context management. AMF also includes network slice selection function (NSSF) and acts as a termination point for the RAN CP interface (N2).

3. **Session Management Function (SMF)**

It is suitable for session management (session establishment, modification and release), UE IP address allocation and management, DHCP functions, termination of related NAS signaling, session management, DL data notification and traffic steering configuration UPF traffic routes.

4. **User Plane Function (UPF):**

It acts as an external PDU session point for packet routing and forwarding, packet inspection, QoS handling, interconnects with the Data Network (DN), and is an anchor point for intra- and inter-RAT mobility.

5. **Network Exposure Function (NEF):**

It supports exposure of capabilities and events, secure provision of information from external applications over the 3GPP network, and internal/external information translation. It acts as an API gateway that allows external users, such as enterprises or partner operators, the ability to monitor provision and enforce application policies for users within the operator's network. Thus, it

    a) It supplies security when services or Application Functions (AF) access 5G Core nodes

    b) Acts as a proxy, or API integration point or translator in the core network

6. **NF Repository Function (NRF):**

The Network Repository Function (NRF) searches for network function instances. When it receives an NF discovery request from an NF instance, it provides the discovered NF instances. It is not present in 4G. It maintains/supports

    a. Profile network of network function (NF) instances and their supported services

    b. Service-based interface, management and maintenance

In SBA, the NF Repository Function (NRF) provides service discovery between individual network functions. It maintains profiles of network function instances and their supported services (for example, function IDs, function types, network slice identifiers, capability information, supported services, and endpoint information such as IP addresses). In this sense, it is one of the important "keys" in SBA.

NRF plays an important role in setting up a new session. Here, a selection request is initiated by the AMF when a request to SMF search and establish a data session is received from the UE. NRF is used to help find and select the right SMF. In the network slice context, the same process occurs: the AMF asks the NRF to select the SMF that is part of the network slice instance based on the S-NSSAI, UE subscription profile and operator policy, when the UE requests to set up a session.

7. **Policy Control Function (PCF):**

It implements the Unified Policy Framework, provides policy rules to CP functions, accesses subscription information for policy decisions in the UDR. It provides a policy framework 8 that includes network slicing, roaming and mobility management. This is similar to the existing policy and charging rule function - PCRF of 4G.

8. **Unified Data Management (UDM):**

It stores customer data and profiles and generates authentication and key agreements (AKA) credentials, user identity handling, access authorization, and subscription management.

9. **Application Functions (AF):**

An application function (AF) resembles an application server that can communicate with other control-plane NFs. AFs may exist for different application services and may be owned by network operators or trusted third parties. For example, an over-the-top application's F provider may

influence routing, directing its traffic to its external edge servers. For services considered trusted by the operator, the AF can directly access network functions untrusted or third-party AFN.

10. **Data Network (DN):**

It refers to the external data network through which operator services, third party services etc. can be accessed.

This new representation of the 5G core architecture in terms of network functions (for example, Access Management Function (AMF) in the control plane) enables other authorized networks functions to access their services. Communication with these nodes leverages an HTTP based API, Changing protocols such as diameter. This marks a major change in the telecom world. Adoption of stateless functions, API based interfaces and move towards. The overall design and their potential benefits include:

a. Flexible and extensible architecture
b. Easy integration with third party software using application programming interface (API)
c. Multi-slice User Equipment (UE), a single UE connecting to multiple simultaneously Services on multiple slices with optimal access and mobility signaling.
d. Improved QoS

Core Network of Service Based architecture

A "service-based architecture" (SBA) is a modular architecture that focuses on services that can register themselves to provide specific services and subscribe to other services, and by using them as building blocks, more complex services can be provided. Adopted by 3GPP Service-based architecture of 5G core system. This is significantly different from 4G, where such modularity is not included in the network elements that make up the core network. SBA facilitates the adoption of virtualization, providing increased flexibility and adaptability to the core network.
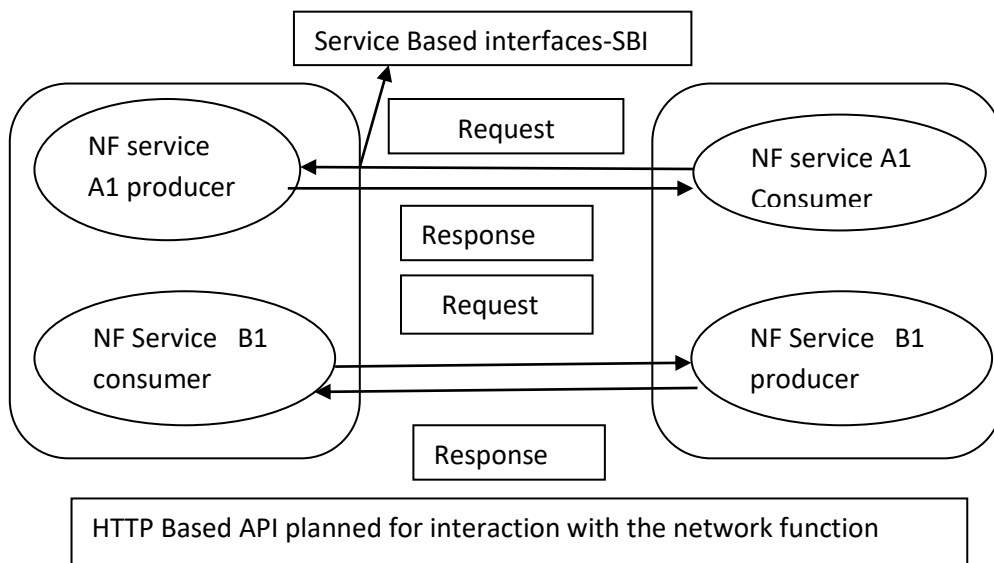

Fig. Core Network of Service Based Architecture

In above diagram is a Core Network of service based architecture in that any one network function is network consumer or a network producer. Any consumer want service consume request to the network function and network function service replay to the consumer.NF is a network function when A want some information about B to send service request to B network function B given the response. This are communication base upon HTTP based API .In above diagram interface is service based interfaces.NF is known as end of service based operation.

To make applications more flexible, scalable, and dynamic, applications have been made deconstructed into smaller and smaller components that can be reused for other applications they can also develop, test and deploy independently. These units are called micro Services Micro services is an architectural design pattern around which systems are composed of Small granularity, highly integrated, and loosely-coupled services. Each of these services fulfills a Specific functionality and is self-contained. Interoperability between services enforces standards Light-weight interface (eg comfort principles etc.). This concept of the software world has been adopted in the telecommunications domain where each network component, which performs certain functions, is divided into component parts and can perform each network function. Register, search, and use services offered by other functions. The Service-based architecture brings following benefits to 5G:

1. Easy update of Network:
    i. Finer granularity allows individual services to be upgraded with minimal impact to other services.
    ii. Facilitated continuous integration reduces the time-to-market for installing bug fixes and rolling out new network features and operator applications.
2. Extensibility:
    i. Light-weighted service-based interfaces are needed to communicate across services.
3. Modularity & Reusability:
    a. The network is composed of modularized services reflecting the network capabilities and provides support to key 5G features such as network slicing.
    b. A service can be easily invoked by other services (with appropriate authorization), enabling each service to be reused as much as possible.
4. Openness.

III. CONCLUSION

In recent market we have to use 5G Technologies of cell phones within very high speed bandwidth. The 5G core network is providing of required services for commercial success of 5G.The service-based architecture for developed in the 3GPP. A "service-based architecture" (SBA) is a modular architecture that focuses on services that can register themselves to provide specific services and subscribe to other services, and by using them as building blocks, more complex services can be provided. In this paper we have to explain architecture of 5G network.

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